English Cytology.

An Introduction to the Study of Cytology. By Prof. L. Doncaster. Pp. xiv + 280 + xxiv plates. (Cambridge: At the University Press, 1920.) Price 21*s.* net.

THE publication of this volume is to be regarded as an event in the progress of cytology. Prof. Doncaster's new book is not intended to serve as a text-book on cytology, though it contains a wealth of facts; but its aim is to interest the senior student in the subject by pointing out the way in which cytology is related to the great fundamental problems at the root of all biological research. Quite recently Paul Buchner, of Munich, published a new "Handbuch" of cytology, and it is with pride that we compare the work before us with its German prototype. A great deal of the material in Prof. Doncaster's book is new, and the work is as strictly up-to-date as is possible when one is dealing with a vast and changing subject such as cytology.

The author's conception of the cell is very broad; he recognises the important part played by the nucleus, but pays due attention to the Golgi apparatus and mitochondria, which he considers may be of special importance in the life of the cell; useful discussions on the structure of protoplasm, such as are illustrated by Hardy's work, and on Hertwig's conceptions of the "karyoplasmatic ratio," are added to this part of the book. The question of the origin and relationships of the centrosome has been treated in a masterly way, and the author shows how J. W. Jenkinson's work on the fertilisation of the Axolotl can provide a middle way between the divergent views—that centrosomes arise from pre-existing centrosomes, and that they may be formed *de novo* in the cytoplasm.

Prof. Doncaster steers a careful course through the troubled waters surrounding the various questions with regard to astral rays, spindle fibres, and "mitokinetism." He gives a fair and lucid *exposé* of the various ingenious hypotheses brought forward to explain mitotic division, but concludes that, at present at least, no really satisfactory explanation of the phenomenon of mitosis has been given.

Students of cytology are often turned away from entering into the various problems associated with the behaviour of the chromosomes in the germ-cell cycle by the fact that the whole question is obscured by a multitude of ill-digested descriptions, theories, and hypotheses. Prof. Doncaster has written an exceptionally clear and able account of the typical behaviour of the chromosomes. Never polemical, he gives a straightforward account which includes on a broad basis all the most modern work on the chromosomes. His first description of maturation is written with an eye to his later accounts of the chromosomes in sex and Mendelism, but he is careful not to confuse his preliminary survey by bringing in debatable matter. Here the student will find a conveniently introduced *résumé* of the Chiasmatypy hypothesis of Janssens, which has gained such prominence among Mendelians.

The modern work on the behaviour of the cytoplasmic inclusions during spermatogenesis has been the subject of careful descriptions. Prof. Doncaster has treated the matter in an able manner, and the worker unacquainted with the Golgi apparatus and mitochondria will find in this book a readable and accurate account of the present state of our knowledge. The various questions surrounding the formation of egg yolk are not treated at length, and should be included in a future edition; we refer especially to the work of Weigl, Hirschler, Rio Hortega, etc. The author exhibits a commendable scepticism with regard to the specificity of the so-called "chromatin" dyes, and points out in several parts of the book that cytoplasmic bodies unrelated to chromatin may stain basophil, and yet not be true chromatin.

In his chapter on segmentation Prof. Doncaster succeeds in bringing out the fact that we have really proceeded a very short distance in the elucidation of the great problems surrounding even the first stages of animal development. In a later part of the book the author discusses some of these problems.

The subject of parthenogenesis is treated at length, and the author draws freely from his own researches on this fascinating subject. He recognises four main sections with regard to the behaviour of the chromosomes in naturally parthenogenetic animals. We are sorry to see that he has not adopted Sir Ray Lankester's suggestions as to the nomenclature of parthenogenesis. In his treatment of the subject of artificial parthenogenesis Prof. Doncaster points out that there are numbers of problems which are still unsolved with reference especially to the determination of sex. The question of the restitution of a diploid chromosome number in some artificially parthenogenetic animals is also peculiar, and its mechanism ill-understood. A special chapter on the chromosomes in sex-determination has been added, somewhat on the lines of the author's "Deter-

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mination of Sex." The peculiar position of Lepidoptera and Aves with regard to these matters is emphasised.

A welcome section on "Germ-cell Determinants" gives clearly the main facts which have been ascertained. The author is commendably cautious in his discussion of this interesting subject, and recognises that "although these bodies are evidently strictly correlated with the germ-cells, there is no absolute certainty that they are the cause of the differentiation of germ-cells from body-cells."

Most cytologists will concur with Prof. Doncaster in his view that the weight of evidence is in favour of the main theory of the individuality of the chromosomes; the author emphasises the fact that the chromosome itself is in all probability divisible into smaller units, which may have an individuality more fundamental than the chromosome as a whole, and he suggests that the individuality theory should be extended so as to regard these granules (microsomes) as the fundamental units.

The chapter on the mechanism of hereditary transmission introduces a discussion on the most recent work on Drosophila and Abraxas. Prof. Doncaster is here dealing with a subject which he has himself studied specially, and though he treats the question with impartiality, he comes to the conclusion that not only does the behaviour of the chromosomes in the maturation divisions of the germ-cells provide the mechanism required for Mendelian segregation of characters, but also that the work of Morgan on Drosophila carries us a step farther and gives us some idea how the groups of characters may be related to special chromosomes. The author recognises the difficulties with regard to our full acceptance of the theories of Morgan and his colleagues relating to the mechanism of "coupling" and "crossing over," but states that no other hypothesis which has been brought forward fits the main facts so well. He concludes his book with an essay on the *rôle* of the cytoplasm in heredity, and gives a good account of the organ-forming substances.

Arranged and written as it is, this book is certain to stir up interest in the subject of cytology. By pointing out the perfections and defects of our present-day basic cytological theories and hypotheses, the author has succeeded in emphasising the lines along which fruitful research may be followed. We hope that this book will mark the beginning of greater activity among English cytologists. Prof. Doncaster is to be congratulated warmly on this excellent work. J. B. G.

Matrices.

University of Calcutta: Readership Lectures: Matrices and Determinoids. By Prof. C. E. Cullis. Vol. ii. Pp. xxiii + 555. (Cambridge: At the University Press, 1918.) Price 42*s.* net.

THE history of the mathematical term "matrix" is likely to be very interesting. Its original meaning was an array of symbols (a_{mn}) forming a rectangle of m rows and n columns, out of which determinants were selected by picking out columns (or rows) of the array. A square matrix gives only one associated determinant, but a square matrix is not the same thing as a determinant.

When we change from one set of variables to another by linear relations

$$y_j = \sum_i a_{ij} x_i \quad (i=1, 2, \ldots n; j=1, 2, \ldots m),$$

we have an associated matrix (a_{mn}), or A, which is square only when the number of variables is the same in each set. In practice this is the most usual case, and it will be simpler to confine ourselves to this for the present. If we take a new set of variables z_i such that

$$z_j = \sum_i b_{ij} y_i,$$

we have a matrix $B = (b_{nn})$, and by eliminating the symbols y_i we deduce

$$z_j = \sum c_{ij} x_i,$$

where the symbols c_{ij} are derived from A, B by a process of "composition," and form a new matrix C. We write C = AB symbolically, and thus start the theory of the multiplication of matrices. There are many analogies with the theory of groups; for instance, BA must be distinguished from AB, multiplication is associative, and so on.

Cayley seems to have been the first to develop the theory of square matrices from this point of view (Phil. Trans., vols. cxlviii., clvi., and elsewhere); other English mathematicians, such as Sylvester, Buchheim, and Tait, took up the subject later on. It may be specially noted that H. Smith's memoir on linear indeterminate equations and congruences contains a great deal of the fundamental theory of matrices, both square and rectangular. In particular, there is a complete and, we believe, original statement of the existence and properties of the elementary factors of a determinant the elements of which are ordinary integers. Weierstrass, Kronecker, and Frobenius, especially the last-named, have made important contributions to the subject.

It will be seen that a matrix is now not merely a scheme of symbols used to specify a set of deter-

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